Geographic Information System-Analytical Hierarchy Process (GIS-AHP) Analysis of Public Transport Accessibility to Mindanao State University-Iligan Institute of Technology (MSU-IIT) Among Iligan City Barangays

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Abstract: This study evaluated public transportation accessibility to Mindanao State University–Iligan Institute of Technology (MSU-IIT) across twenty-two surrounding barangays. A multi-criteria framework integrating the Analytical Hierarchy Process (AHP) and Geographic Information Systems (GIS) was utilized. Eight spatial parameters were assessed: road network density, travel time, proximity to Public Utility Jeepney (PUJ) routes, waiting time, registered fleet units, route circuity, land use, and terrain steepness. Expert judgments established the parameter weights through AHP, which were subsequently integrated with reclassified spatial raster data using a weighted linear combination in GIS to generate a continuous accessibility surface. The AHP established road network density and travel time as the primary drivers of transport accessibility. The resulting spatial index revealed profound inequity: western urban corridors exhibited very high accessibility, while eastern peripheral barangays registered very low accessibility. These spatial maps serve as deterministic diagnostic tools for local authorities to optimize public transportation networks and systematically resolve transit deserts.

Keywords: *Accessibility, Analytical Hierarchy Process (AHP), Geographic Information System (GIS), Multi-Criteria Framework, Reclassified Spatial Raster.*

1.INTRODUCTION

1.1 Background of the Study

Public Transportation is the backbone of mobility in urban and semi-urban environments, allowing people to access critical services.(Alamri et al., 2023) In developing nations like the Philippines, it is important to conduct a systematic public transportation assessment to identify underserved areas and address spatial imbalances, which become highly apparent during peak hours (Mayo &Taboada, 2020).

Iligan City is a highly urbanized city in Northern Mindanao with a land area of 813.37 square kilometers and a population of 363,115 as of the 2024 Census, making it the largest city in Lanao del Norte in both population and land area (PSA, 2024). Jeepneys continue to be the

most popular form of public transportation in Iligan City. This is in line with the general trend in Philippine cities, as traditional public utility jeepneys continue to be the most popular paratransit mode despite continuous modernization attempts (Sunio et al., 2025). But not every barangay has equal access to these services, which leads to differences in commuters' total mobility (Nogueira and Diaz, 2023).

In Iligan City, Mindanao State University–Iligan Institute of Technology (MSU-IIT) is a significant center for public education. The campus, which is home to seven CHED Centers of Excellence and regional research centers, attracts a regular commuter base from all over the Mindanao region and is home to about 13,000 students and staff (MSU-IIT, n.d.). Because spatial infrastructure deficiencies result in socio-spatial disparities and higher commute expenses for the student population, evaluating public transportation accessibility for this institutional center is essential (Mayo and Taboada, 2020). Physical mobility may be restricted by local route network constraints, which has an impact on institutional involvement (Lucas, 2019). By using objective data frameworks to analyze these transportation networks, it is possible to enhance geographical distribution and promote the creation of sustainable municipal infrastructure (Cheng et.al, 2015).

1.2 Statement of The Problem

Public transportation accessibility to MSU-IIT plays a vital role in supporting mobility and enhancing connectivity across Iligan City. However, the lack of comprehensive spatial database for transport planning limits the capacity to evaluate which barangays are adequately served and which remain underserved. Accessibility levels vary significantly across barangays, resulting in unequal commuter experiences. While accessibility is a recognized cornerstone of urban planning, localized studies applying proven transport metrics within the Iligan context remain scarce. Using a weighted set of geographic and transport parameters validated by existing literature, this study addressed the problem: which barangays exhibit high, medium, and low accessibility to MSU-IIT as determined by spatial accessibility scores and multi-criteria evaluation visualized using GIS?

1.3 Objectives of the Study

This study evaluated public transportation accessibility to MSU-IIT across 22 barangays in Iligan City through a GIS-AHP-based assessment framework. Specifically, it sought to: (1) determine and rank accessibility parameters using the Analytic Hierarchy Process (AHP); (2) quantify each barangay's level of public transportation accessibility to MSU-IIT using the identified parameters; (3) generate individual spatial maps for each accessibility parameter using Geographic Information Systems (GIS); and (4) produce an overall spatial accessibility map reflecting the aggregated public transportation accessibility scores of barangays bound to MSU-IIT

2. REVIEW OF RELATED LITERATURE

This section integrates multidimensional frameworks to evaluate public transportation accessibility, a foundational element of sustainable urban infrastructure that is necessary for minimizing private vehicle dependence (Droj and Badea, 2022). Comprehensive spatial methodologies are crucial, as single-indicator models fail to capture real-world commuting challenges or the compounding temporal and financial costs that affect institutional

destinations during peak periods (Mayo and Taboada, 2020). To address these analytical limitations, combining Geographic Information Systems (GIS) with the Analytic Hierarchy Process (AHP) provides a robust framework for balancing diverse spatial criteria through expert pairwise comparisons, yielding validated composite accessibility surfaces (Saaty, 1980; Saaty and Vargas, 2012). Consequently, this mathematical integration ensures that structural, temporal, and environmental factors are systematically weighted to provide an objective, high-resolution representation of regional public transportation equity (Geurs and van Wee, 2016).

The specific parameters utilized within this spatial index are thoroughly substantiated across contemporary transportation literature. Road network density, a validated predictor of baseline urban accessibility in GIS modeling, captures structural network connectedness (Sahitya and Prasad, 2021). Travel time, which is still the most often used metric for mapping spatial friction, is used to directly assess operational network costs (ElDeeb et al., 2024). Additionally, by calculating differences between actual trip pathways and straight-line distances, route circuity ratios reveal design inefficiencies (Dixit et al., 2021). Together with temporal factors, environmental factors, more especially, the distribution of land use and the steepness of the terrain, act as important physical determinants that affect student mobility (Zannat et al., 2020). Together, these factors set up the geographic model's structural underpinning, guaranteeing that both environmental limitations and rigid physical layouts are represented mathematically.

Supply measurement accessibility factors offer crucial context for availability and localized service frequencies. Average waiting times, which closely resemble headway durations recorded in Philippine service contracting evaluations, are the main measures of public transit supply performance (Sunio et al., 2025). According to Guo et al. (2020), a trustworthy indicator of overall service capacity is the number of operational, registered public transportation units within localized bounds. Passenger wait times increase when vehicle availability falls short of localized commuter demand, which directly reduces overall transport access and exacerbates public transportation disparities across disadvantaged sectors (Guo et al., 2020). By taking these operational variations into account, the GIS model is guaranteed to accurately depict service availability rather than assuming a consistent frequency of public transportation over structurally connected roads.

While existing studies collectively established theoretical and methodological foundations in assessing Transportation accessibility, these studies remain largely saturated in highly urbanized multi-modal transit environments. Localized applications within mid-sized cities dominated by Public utility jeepneys and complemented by informal modes of transportation , remain limited. This study addressed that gap by applying a GIS-AHP framework in assessing public transportation accessibility across Iligan City barangays surrounding Mindanao State University-Iligan Institute of Technology.

3. METHODOLOGY

3.1 Research Design and Study Area

This study adopted a descriptive-analytical approach to assess the public transportation to MSU-IIT for 22 barangays in Iligan City located within a 5-km radius of the university. A multi-criteria decision analysis (MCDA) framework was utilized, using AHP to mathematically derive parameter weights based on expert judgments, while GIS served as the spatial tool to model accessibility as a continuous surface. By discretizing the study area into high-resolution grid cells, this modeling approach allows for a continuous representation of accessibility.

3.2 Analytical Hierarchy Process (AHP)

Eight parameters were selected for the analysis: land Use, road Network Density, travel Time, proximity to PUJ routes, route circuity, waiting time, number of registered Units, and terrain Steepness. Ten expert respondents were selected from relevant local institutions, namely the City Engineer's Office (CEO), Department of Public Works and Highways (DPWH), and the Iligan City Traffic and Parking Management Office (ICTPMO). The selected respondents provided judgments for the pairwise comparison process using Saaty's 9-point fundamental scale. Individual judgments were aggregated by calculation of the geometric mean, and parameter weights were extracted through matrix normalization. To ensure the integrity of expert inputs, a Consistency Ratio (CR) was calculated using standard AHP procedures.

3.3 GIS Spatial Processing

3.3.1 Land Use

Satellite imagery from the ArcGIS World Imagery Basemap was overlaid onto the boundaries of the study area. Google Maps Street View was used to cross-reference the land use zoning. Vector polygons were created based on areas with similar land use. These polygons were given an accessibility score and then converted using the Polygon to Raster tool.

3.3.2 Road Network Density

The road network vector lines for Iligan City were extracted from the OpenStreetMap (OSM) data. Using the Line Density Spatial Analyst tool, the software calculated the density of linear features within the neighborhood of each pixel. This generated a smooth heat map representing the density of street infrastructure across the study area.

3.3.3 Travel Time

Travel time was modeled as the Cost Distance of the road networks divided by the maximum allowable speeds of each road in accordance to statutory provisions (30 km/h for primary roads, 20 km/h for secondary and tertiary roads, and 10 km/h for barangay roads). The calculation is expressed as:

$$Travel\ Time = \frac{Cost\ Distance}{Max.\ Allowable\ Speed} \quad (1)$$

where:
$Cost\ Distance$: actual physical distance of the road network
$Max.\ Allowable\ Speed$: statutory speed limit assigned per road classification.

3.3.4 Proximity to PUJ Routes

The official PUJ routes were digitized based on the Local Public Transport Route Plan (LPTRP) from the ICTPMO. To reflect varying levels of accessibility, the Euclidean Distance tool was

used to generate a continuous distance surface, reflecting the coverage of the routes in 100-meter intervals.

3.3.5 Route Circuity

First, a Cost Distance raster was generated for all roads to calculate the actual physical distance (in km) from every pixel to MSU-IIT. Second, a Euclidean Distance raster that represented the straight-line distance was utilized. Using the Raster Calculator, the Cost Distance raster was divided by the Euclidean Distance raster on a pixel-by-pixel basis, expressed in the equation:

$$Route\ Circuity = \frac{Cost\ Distance}{Euclidean\ Distance} \quad (2)$$

where:
$Cost\ Distance$: actual physical distance of the route to MSU-IIT
$Euclidean\ Distance$: theoretical straight-line distance to MSU-IIT.

3.3.6 Waiting Time

Because PUJs operate without rigid timetables, an Adjusted Headway Model was utilized to simulate effective commuter wait times. The calculation incorporates route length, allowable speeds, and active fleet size, alongside uniform heuristic penalties for road congestion (C_f), terminal dwell time (D_t), and capacity denial (P_c) derived and scaled from established deterministic transit models (Liu et al., 2021; Safiullin & Arias, 2024), expressed in the equation:

$$WaitingTime = \left[\frac{\left(\frac{Length,km \times 2}{Speed,\frac{km}{h}} \times C_f\right) + \frac{D_t}{60}}{Fleet\ Size}\right] \times 60 \times P_c \quad (3)$$

where:
$Length$: actual route length in kilometers
$Speed$: allowable vehicular speed
D_t : uniform terminal dwell time penalty
C_f : uniform road congestion penalty
P_c : uniform capacity denial penalty
$Fleet\ Size$: total number of active registered units.

3.3.7 Number of Registered Units

Using franchise data from the ICTPMO and the LPTRP, the active fleet size for each official PUJ route was integrated into the route networks. For overlapping routes, the total fleet count was aggregated to represent the combined transit capacity along shared corridors. This aggregated vector data was then converted into a continuous spatial grid using the Polyline to Raster tool.

3.3.8 Terrain Steepness

Terrain steepness was evaluated to account for the physical constraints that topography imposes on paratransit operations. A Shuttle Radar Topography Mission (SRTM) Digital Elevation

Model (DEM) was processed using the ArcGIS Spatial Analyst Slope tool to calculate the percent rise across the study area.

3.3.9 Public Transportation Accessibility Index (PTAI)

Spatial data were digitized and converted into raster surfaces. Raw pixel values were classified into a five-level ordinal rating scale ranging from 1 (Very Low Accessibility) to 5 (Very High Accessibility). The overall accessibility scores were computed using a cell-by-cell weighted overlay via Raster Calculator. The calculation is expressed as

$$PTAI = \sum W_i * S_i \quad (4)$$

where:
W_i : computed AHP parameter weight, and
S_i : reclassified pixel score.

Finally, the high-resolution raster output was aggregated back to the administrative barangay level using Zonal Statistics to compute the mean Public Transportation Accessibility Index (PTAI) for each barangay.

4. RESULTS AND DISCUSSION

4.1 Pre-Processing of Public Transportation Accessibility Parameters

With the goal to assess public transport accessibility within a 5-kilometer radius of MSU-IIT, the macro-spatial analysis synthesized eight technical parameters (see Figures 1 to 8): road network density, travel time, proximity to PUJ routes, passenger waiting time, registered fleet units, route circuity, land use characteristics, and terrain steepness. As visualized in the spatial maps, Figure 1 illustrates the high concentration of commercial land use in the western core, while Figure 8 highlights the severe terrain steepness dominating the eastern periphery. Furthermore, Figures 2, 3, and 4 demonstrate that dense road infrastructure, PUJ route proximity, and fleet capacities are heavily concentrated in the urban center, which directly contrasts with the high route circuity (Figure 5) and extended travel and waiting times (Figures 6 and 7) prevalent in the outer barangays. The derived spatial index shows a clear geographic separation between the eastern interior regions and the western urban core. Because of the dense concentration of operating public transportation fleets, low route circuity, and high road infrastructure density, the western urban core, represented by Tibanga and Poblacion, has a high concentration of ideal accessibility values. On the other hand, on eastern interior barangays like Puga-an, Luinab, and Upper Hinaplanon, accessibility indicators show a sharp decline from Low accessibility to Very Low.

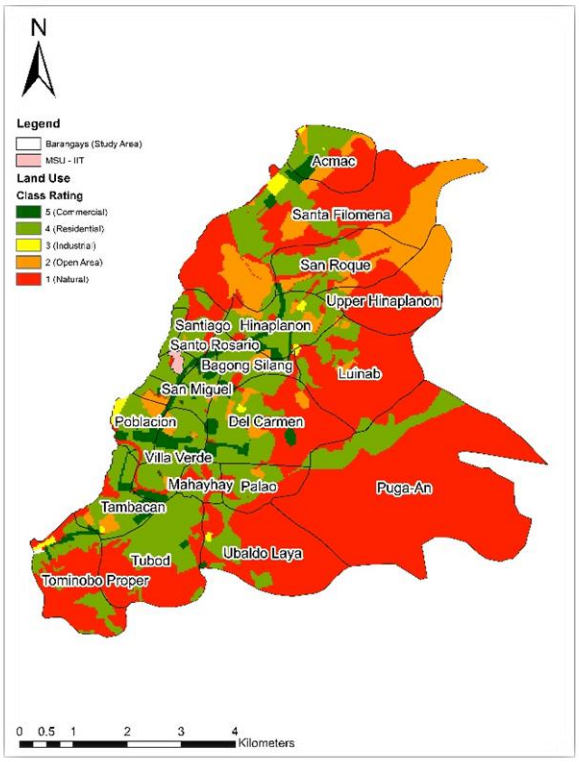


Figure 1. Land Use Map

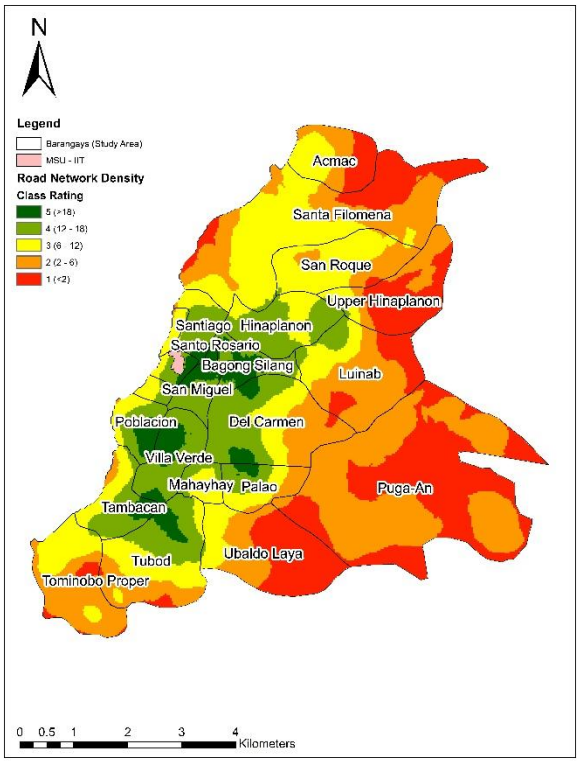


Figure 2. Road Network Density Map

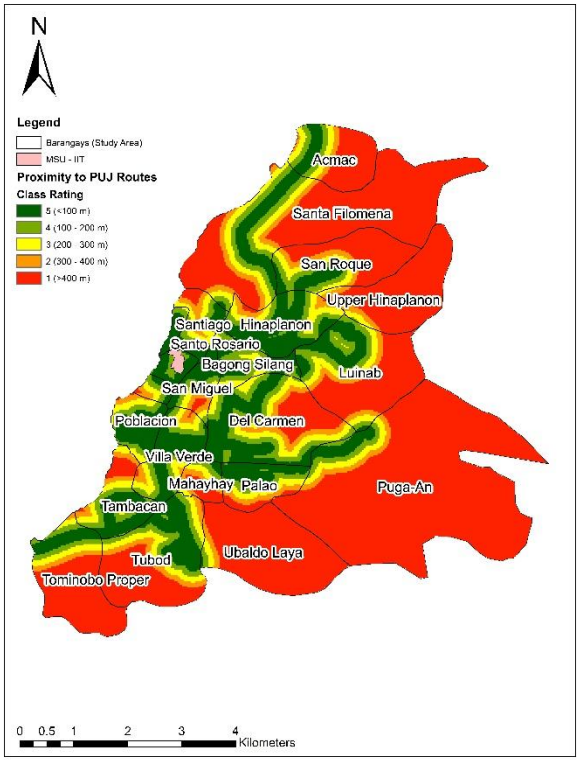


Figure 3. Proximity to PUJ Routes Map

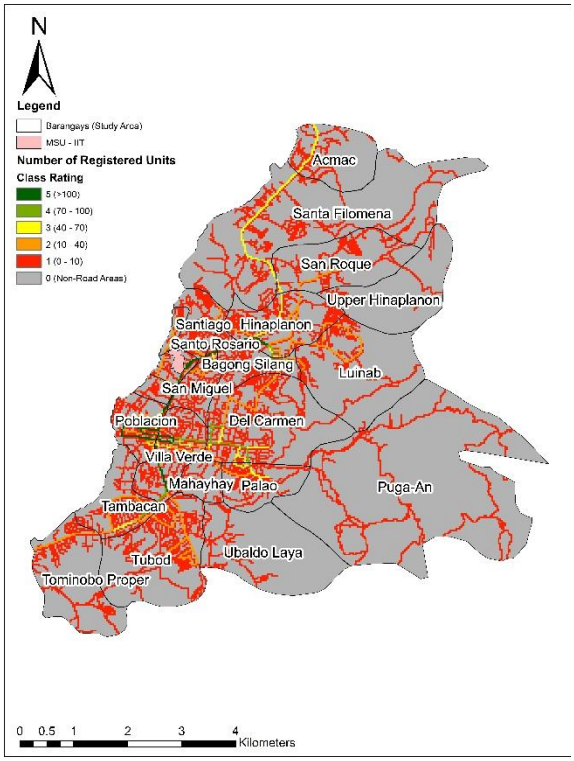


Figure 4. Number of Registered Public Utility Jeepneys Map

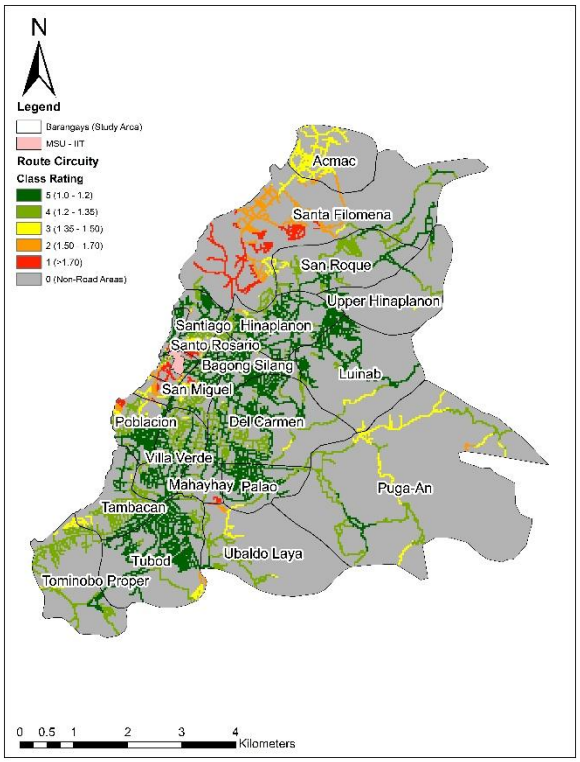


Figure 5. Route Circuity Map

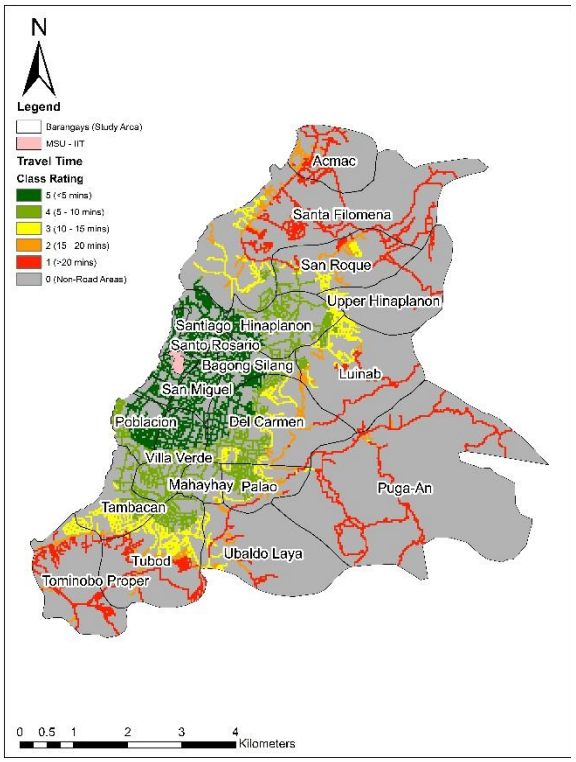


Figure 6. Travel Time Map

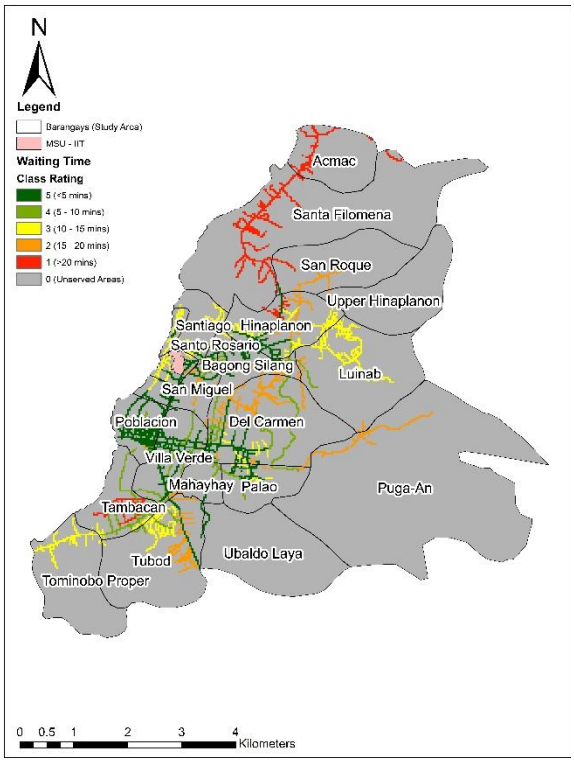


Figure 7. Waiting Time Map

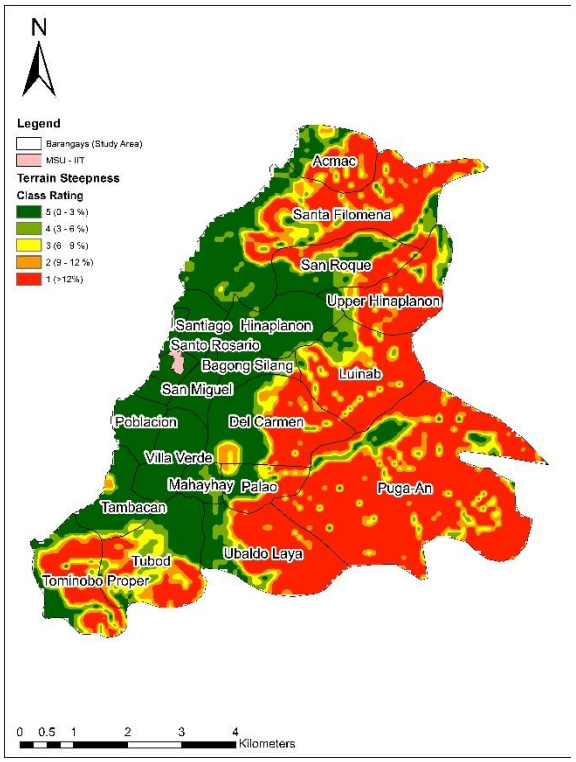


Figure 8. Terrain Steepness Map

4.2 Parameter Weight Distribution

The aggregated AHP pairwise comparison matrix yielded a Consistency Ratio of 0.0053, which is well within the standard 0.10 threshold, validating the high reliability of the expert judgments. Road Network Density was identified as the most influential parameter, receiving the highest weight at 21.622%, followed by Travel Time and Proximity to PUJ Routes at 15.723% and 15.323%, respectively. Terrain Steepness yielded the lowest impact among all eight parameters, with a weight of 3.769%. Table 1 shows the distribution of weights across all eight parameters.

Table 1. Distribution of Parameter Weights

Parameter	**Weight**
Land Use	9.092%
Road Network Density	21.622%
Travel Time	15.723%
Proximity to PUJ Routes	15.323%
Route Circuity	10.043%
Waiting Time	13.684%
Number of Registered Units	10.745%
Terrain Steepness	3.769%
TOTAL	100.00%

4.3 Public Transportation Accessibility Mapping

Eight parameter rasters were integrated using weighted linear combination in the GIS-AHP model (see Figure 9). The output structure was strictly dictated by Road Network Density (21.622%), Travel Time (15.723%), and Proximity to PUJ Routes (15.32%), with the remaining variables moderating local values. As a result, the areas of Tibanga, San Miguel, Poblacion, Villa Verde, and sectors of Tubod and Pala-o were all included in the contiguous dark green cluster of ideal scores that was centered around the MSU-IIT campus. This spatial pattern shows regions with quick PUJ route buffers, short travel durations, and dense, connected road infrastructures that simultaneously satisfy the three major metrics. Additionally, rather of employing uniform boundaries that produce averaged, barangay-wide values, the accessibility index was assessed on a high-resolution raster scale, as confirmed by the varied pixel density mapped directly across public transportation corridors.

In San Roque, Del Carmen, Tubod, and Pala-o sectors, the accessibility map shows transitional yellow and orange pixels, which indicate moderate to poor ratings. Instead of a total network collapse, this geographical band indicates a localized reduction across top-ranked metrics. On the other hand, areas in the north and east, such as Pugaan, inland Tominobo Proper, and the inner corridors of Santa Filomena and Acmac, have poor to extremely low accessibility scores. Due to travel times longer than twenty minutes, low road network density, and significant distances from public utility jeepney routes, these sectors scored in the lowest class across the three highest-weighted metrics, which accounts for the shortfall. Although these eastern regions are visually dominated by difficult terrain steepness, its little 3.769% weight only slightly affects the final public transportation accessibility rating. While these eastern regions exhibit very low public transportation accessibility based on formal PUJ routes, it is important to note that commuters in these topographically constrained areas likely rely on alternative, informal modes of transportation—such as tricycles (*sikad*) and motorcycle taxis (*habal-habal*)—to bridge the spatial gap.

4.4 Mean Public Transportation Accessibility Index per Barangay

The mean Public Transportation Accessibility Index was computed for every barangay (see Table 2) to supplement the spatial patterns with direct numerical comparison. When the values are ranked, Poblacion leads the index at 2.9942, followed by Bagong Silang at 2.9202, both of which only barely outperform Tibanga, the campus host barangay, at 2.9059. Tibanga's mean score includes subpar periphery locations, despite its proximity to MSU-IIT. On the other hand, Poblacion makes significant use of the top-weighted Road Network Density metric and benefits fully from a dense, historic commercial street grid. Because its perimeter is traversed by high-frequency transport lines that maximize waiting times and cumulative fleet supply, Bagong Silang takes second position. Lastly, the fact that public transportation accessibility is still restricted to the city's main metropolitan core is confirmed by a contiguous western cluster that ranges from 2.32 to 2.91.

The middle ranking is occupied by Pala-o, Del Carmen, Mahayahay, Tambacan, and Tubod. Although their ratings are statistically constrained by underserved internal sectors spreading eastward, these barangays avoid the lowest rank because they connect minor roads to key arterial corridors. As a result, averaging these grid cells puts them in the middle tier by balancing peripheral deficits with metropolitan access. On the other hand, Spatial disparities in coverage are exposed by the policy-relevant bottom ranks. San Roque, Luinab, and Acmac score less than 1.35, forming a lower-middle cluster with Tominobo Proper and northeastern parts. Due to a nearly complete lack of road infrastructure, Ubaldo Laya (0.7259), Upper Hinaplanon (0.6987), and Pugaan (0.6589) fall short of one-fourth of the highest mean. A clear metric for focused transportation design is provided by the significant statistical difference between Poblacion and Puga-an

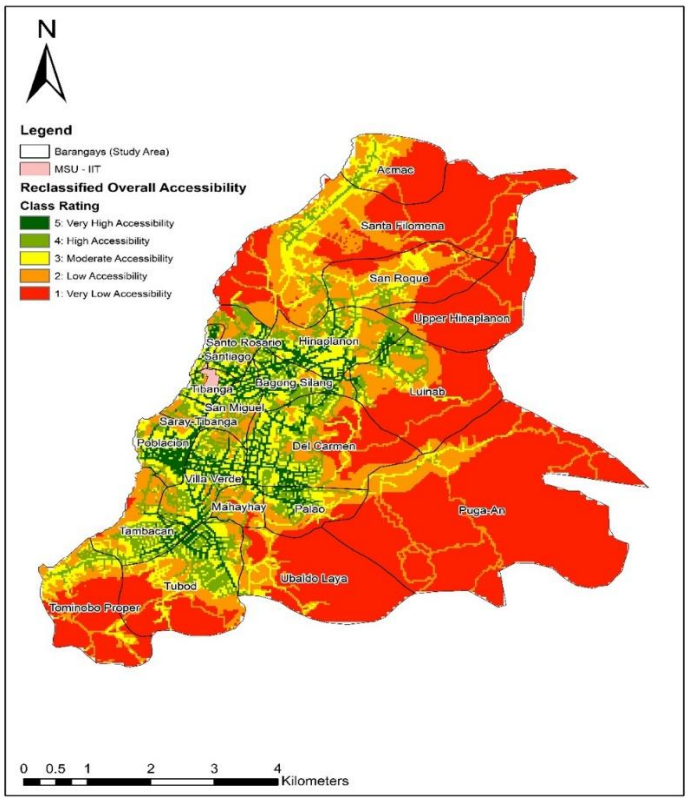


Figure 9. Overall Public Transportation Accessibility Index Map.

Table 2. Mean PTAI for each barangay

Rank	Barangay	Mean PTAI	Rank	Barangay	Mean PTAI
1	Poblacion	2.9942	12	Del Carmen	1.947
2	Bagong Silang	2.9202	13	Mahayhay	1.8069
3	Tibanga	2.9059	14	Tubod	1.6756
4	Villa Verde	2.8818	15	San Roque	1.3472
5	San Miguel	2.8612	16	Luinab	1.1517
6	Santiago	2.7524	17	Tominobo Proper	1.139
7	Hinaplanon	2.5453	18	Acmac	1.1305
8	Santo Rosario	2.5099	19	Santa Filomena	1.075
9	Saray-Tibanga	2.4344	20	Ubaldo Laya	0.7259
10	Tambacan	2.3234	21	Upper Hinaplanon	0.6987
11	Palao	1.9909	22	Puga-an	0.6589

4.5 Distribution of PTAI Class Rating per Barangay

Internal accessibility distributions for each of the five reclassified groups are shown in Table 3, which provides detailed information on regional variation. Among well-served areas, Santiago stands out for having the best internal consistency. Puga-an, on the other hand, exhibits the same homogeneity at the opposite spectrum, with 0 percent presence in classes four and five, which quantitatively validates its nearly complete lack of road infrastructure. Within the research area, Del Carmen has the most noticeable internal dispersion. Its physical arrangement contrasts a significantly underdeveloped eastern region with a well-served western corridor. This substantial internal variance demonstrates that severe socio-spatial public transportation disparities that exist locally within a single administrative border are not captured by aggregate, barangay-wide averages.

Table 3. Distribution of PTAI Class Rating per Barangay

Barangay	Class Rating 1 (%)	Class Rating 2 (%)	Class Rating 3 (%)	Class Rating 4(%)	Class Rating 5 (%)
Acmac	53.03	34.27	12.52	0.18	0.00
Bagong Silang	0.00	34.55	11.15	37.41	16.88
Del Carmen	27.68	35.60	11.67	18.88	6.17
Hinaplanon	0.82	48.55	11.69	28.84	10.11
Luinab	60.13	26.14	5.26	8.39	0.08
Mahayahay	7.84	61.32	19.51	10.10	1.22
Pala-O	18.21	43.90	14.15	17.07	6.67
Poblacion	0.00	35.19	18.11	14.61	32.10
Puga-An	87.31	11.58	1.11	0.00	0.00
San Miguel	0.00	28.37	21.05	31.19	19.38
San Roque	41.23	43.42	11.66	3.35	0.33
Santa Filomena	57.16	34.92	7.41	0.51	0.00
Santiago	0.00	48.44	3.65	39.58	8.33
Santo Rosario	4.34	39.53	12.03	38.98	5.12
Saray-Tibanga	0.00	53.85	13.92	23.81	8.42
Tambacan	1.96	46.85	21.43	26.12	3.64

Barangay	Class Rating 1 (%)	Class Rating 2 (%)	Class Rating 3 (%)	Class Rating 4(%)	Class Rating 5 (%)
Tibanga	0.00	32.47	18.30	35.31	13.92
Tominobo Proper	59.73	28.55	9.48	2.24	0.00
Tubod	36.62	34.23	12.15	14.88	2.13
Ubaldo Laya	82.17	14.18	3.57	0.09	0.00
Upper Hinaplanon	87.16	9.79	3.01	0.04	0.00
Villa Verde	0.00	30.87	18.49	32.84	17.79

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study developed a GIS-based multi-criteria assessment model integrated through the Analytical Hierarchy Process to evaluate the spatial distribution of public transport accessibility to Mindanao State University-Iligan Institute of Technology. Eight different spatial features were mapped and integrated using a derived AHP weighted overlay to create a Public Transportation Accessibility Index Map, which was limited to twenty-two barangays within a five-kilometer campus radius. The resulting reclassified spatial map shows that barangays around the main highway consistently had the greatest rankings, with optimal accessibility levels concentrated along the western urban corridor. On the other hand, the barangays in the eastern periphery had the lowest accessibility scores. Significant internal heterogeneity was seen in mid-range sectors like Del Carmen, underscoring the analytical value of high-resolution rasterization spatial modeling over conventional uniform administrative reporting.

Among the evaluated parameters, Road Network Density emerged as the single most influential determinant of overall transport accessibility, followed immediately by Travel Time and Proximity to PUJ Routes. When taken as a whole, these three top-tier factors make up almost half of the model's overall overlay weight. Expanding public transportation franchise routes or increasing vehicle fleet capacities within low-scoring barangays will yield limited practical benefits without prior investments in foundational road network infrastructure, according to this structural hierarchy, which has important policy implications for municipal development. This mathematical distribution highlights that structural geometry determines the viability of public transportation, which means that before operational public transportation service modifications can successfully increase regional accessibility, localized connection constraints must be addressed by expansion frameworks.

5.2 Recommendations

Future academic research should refine this methodology by integrating different demographic preferences that can be simulated by varying parameter weights, such as highlighting trip times for students against terrain constraints for senior commuters. Additionally, the focus is shifted from a merely geographic layer to a transportation equity analysis by adding localized population density and demographic data, which accurately measures the human impact within low-accessibility zones. In order to replicate real-world traffic changes, future models must also take temporal dynamics into consideration by comparing peak and off-peak hours. Lastly, the precise operational reach of interior circulation networks will be mapped by extending the

research to assess multi-modal networks by accounting for secondary informal transport systems, such as tricycles and ride-hailing services.

The empirical data gives local public transportation authorities a spatial roadmap for optimizing public networks through fleet reallocations and targeted route extensions. To meet unmet commuter demands, heavily underserved areas like Pugaan, Tominobo Proper, Santa Filomena, and Acmac need to create developing franchise lines and expand vehicle capacity. Agencies should give priority to modernizing active transportation infrastructure in interior areas where expanding regular public utility jeepney routes is physically limited by topography. By making investments in formal public transportation terminals, pedestrian corridors, and sidewalk rehabilitations, structural friction is reduced and peripheral commuters can securely access key transportation routes. These focused structural interventions guarantee that operational changes result in quantifiable gains in spatial equity and regional network connection.

Lastly, to address localized bottlenecks and shorten travel times, targeted traffic management interventions are needed in intermediary sectors like San Roque, Del Carmen, and peripheral Pala-o. In order to maximize speeds, authorities must enforce stringent loading limits, remove unlawful street parking, and maintain ongoing pavement restoration because physical road-widening is limited by urban congestion. In the end, high-resolution spatial mapping should be fully institutionalized as a standard tool for policy-making inside the local government unit. Planners can identify specific parameter deficiencies inside particular barangays by using rasterized geographic information systems. This data-driven strategy ensures that urban transport investments are allocated effectively to address structural socio-spatial public transportation disparities throughout the city by substituting tailored municipal interventions for broad, generic policies.

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